ISSN 2249-6343
International Journal of Computer Technology and Electronics Engineering (IJCTEE)
Volume 3, Issue 2, April 2013

An Embedded1/3 Phase Automatic Transfer Switch Controller with Intelligent Energy Management

Autade Prerana P., S. G. Galande

***Abstract*— "PROTOGEN" is a 3-phase Automatic/Manual Generator Controller module that includes protection for GEN-SETS. Use of advanced micro controller in the design platform provides easy and trouble free control and operation mechanism of GEN-SETS in case of failure of mains power. Upon failure of mains power (due to faults like loss of power, over voltage, under voltage, phase reversal, phase unbalance etc.), "PROTOGEN" initiates "Automatic GEN-SET Start Cycle" including transfer of load to GEN-SET by using the Generator contactor. As and when the mains power gets restored, the load gets automatically transferred back to the mains line and the GEN-SET stops after a cool-down time. During the cycles, the GEN-SET is protected against malfunction. All alarms occurring at abnormal GEN-SET conditions are computed and displayed either by LED or on LCD through alphanumeric messages.**

Keywords-ATS (Automatic Transfer switch), LCD (Liquid crystal display), LED (Light emitting diode).

I. INTRODUCTION

A typical stand by power system includes a generating set operating on diesel, fuel or natural gas and one or more automatic transfer switches. The system will also have a number of accessory components such as battery charging equipment, fuel pumps, ventilation fans, and other equipments. The transfer switches direct power to critical loads from either a utility service or your generator set.

Most 'failures' in the utility power supplied to facility are not failures of the large central stations providing power, but rather failures in power distributions system serving the facility. Failures can occur due to damage the part of utility system, failure of distribution component, or overload of distribution system. For example, if a car drives of the road and knocks down a power pole, it's not surprise that customers who are served by the lies on that power pole will have a disruption in power. However all the customers affected by the downed line may not have to wait until the line is repaired to get power back. Just as a facility with a generator set usually has the equipment to automatically detect problems and respond, the utility distribution system includes equipment to automatically detect the problem and return power to their customer as fast as is practical. These systems may re-route the power from anther source, or may attempt to re-feed the failed part of the system. In many cases the damaged part of the system is isolated so quickly that customers don't even notice a problem[3].

II. TRANSFER SWITCH OPERATION

There are wide varieties of transfer switches available, though many different manufactures. Variations that are available include manual operation, automatic open transition and closed transition operation sequences (some with mechanical bypass capability), closed transition load ramping devices, and solid-state types. The most common type of ATS, and the one we will look at in detail is an automatic electro-mechanical device that operate in an open transition sequence."Open Transition" means that the switch disconnect load from one source before it connects to another source. So, whenever the transfer switch operate from source to source there is short (fraction of second) power failure. The timing function and setting practice discussed in this document will be applicable for most types of transfer switches.[1]

A. ATS Setting for best operation

First, recognize that it is normal for voltage of the power service to your home or facility varies somewhat over time and is different in different location. So, if you set up a transfer switch to start the generator set at 90% of normal level, it might start a lot of times! Also, the typical voltage level at your home or facility varies over time depending on a number of other conditions. It's possible that it might normally be a little higher or a little lower than the nominal 120 volt level that is intended. That won't cause any problem, but it should be considered in the decision of how to set up your transfer switch.

ISSN 2249-6343
International Journal of Computer Technology and Electronics Engineering (IJCTEE)
Volume 3, Issue 2, April 2013

Determine if the transfer switch serves emergency loads, ifdo, you need to get a problem sensed quickly, and the ATS must connect to the sensed quickly, and the ATS must connect to the genset in 10 second or less. A key factor in the setting is how long it takes to get the generator set started and up too proper speed and voltage. This varies somewhat with the size normal service after a preset time delay, most transfer switches can be set up to stay connected to the generator set until an operator signals that retransfer can be done. These facilities include loads that are sensitive to perform the retransfer to normal power, the loads are not disrupted at a when users will notice the problem.

B. Pre-Transfer signals for best operation

Some loads, such as elevator and some types of cash register systems are disrupted when there is a sudden loss of power and a short time later, a sudden return of power. For example, if you have ever been in an elevator when [power fails, you know that the elevator immediately stops, and the stopping point may ell be between floors. If the elevator control system is confused by the sudden failure in power in power or return of power. A signal to tell the elevator controller that the ATS is about to operate can allow the elevator to move to the next available control, open the doors and wait. Then while the power is failed no one is trapped in the elevator. The power can then turn off without incident. The pre=-transfer signal is also used if the transfer switch operate too quickly from live source to live source. Again, the signal allows the load to turn off, the switch to operate, and then the load can turn on again without causing disruption in the facility distribution system or damaged to the loads.

C. Switched neutral (4-pole) Transfer switches

Transfer switches that serve three-phase/four-wire loads can be either 3-pole or 4-pole (switched neutral) type transfer switches. The physical differences between 3-pole and 4-pole transfer switches are shown in the illustration below. In a 4-pole transfer switch, all the phase poles plus the neutral are provided with power transfer contacts. In a 3-pole transfer switch, the neutral does not utilized power transfer contacts, but rather is provided with a solid bus-bar connection point.4-pole transfer switches are used in 277/480VAC application where the facility power distribution system incorporate ground fault protection.

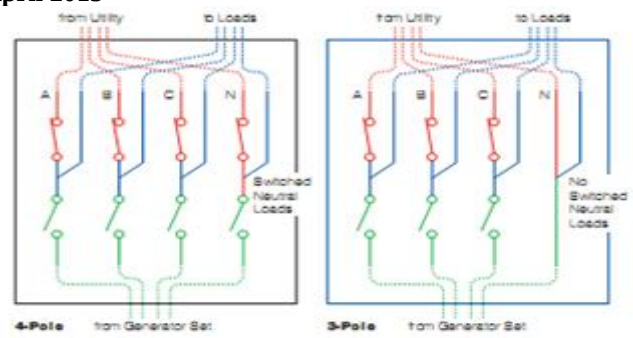

Fig1.A 4-pole transfer switch incorporates a switched neutral, while a 3-pole ATS has a solid neutral[8].

D. Frequency sensing

Frequency sensing is normally provided on the generator source for the purpose of monitoring of an ATS so that the user can be sure that the generator set is operating at the proper speed prior to connecting loads. Most modern generator set automatically adjust voltage as a function of speed, making it unlikely that the generator set will operate at improper voltage and improper speed, but some codes still require this feature.

Frequency sensing is also available as an optional feature for utility source. This feature is primarily designed for application where there is a weak utility grid.(A weak utility grid is one in which the grid is relatively low in capacity relative to the largest loads in the system. In a weak grid environment frequency variation will occur which are not present in stiff grid system, such as a common in North America.) Frequency sensing on the utility source can be used to detect potentially disruptive frequency swing on a weak grid, or as another factor in qualifying source acceptability.

E. Programmed Transition

Transfer switches that serve large motor loads (greater than 20Hp), UPS, and other inductive loads are often provided with programmed transition capability. When inductive load are disconnected from a power source, they produce output voltage for a short period of time. If the ATS switches too quickly from source to source, the load generated voltage is parallel to the out coming source voltage. Interconnecting voltages from multiple sources that are not synchronized will cause damage to loads, and nuisance tripping of circuit barkers. To prevent this problem, the transfer switch operating speed from source to source is intentionally slowed down, so that the load generated voltage delay to a safe level before they are connected to the new source.

ISSN 2249-6343
International Journal of Computer Technology and Electronics Engineering (IJCTEE)
Volume 3, Issue 2, April 2013

F. Phase angle sensing between sources (In-phase monitor, phase check)

Transfer switches that don't have the ability to control operating speed can be provided with phase angle sensing to allow the sources to drift into synchronization before the ATS switches between live sources. This can mitigate the effects of fast switching of inductive loads, but is not 100% effective.

G. Automated exercising(tests ATS and exercise genset)

Most transfer switches incorporate timers to automatically initiate testing and exercising of a generator set. Generator sets are typically exercised (run under load) once per month for 30 minutes. When the ATS load is used for exercising the genset, the exercise provide the dual purpose of testing the operation of the transfer switch so this is recommended practice.

III. SCHEME OF IMPLEMENTATION

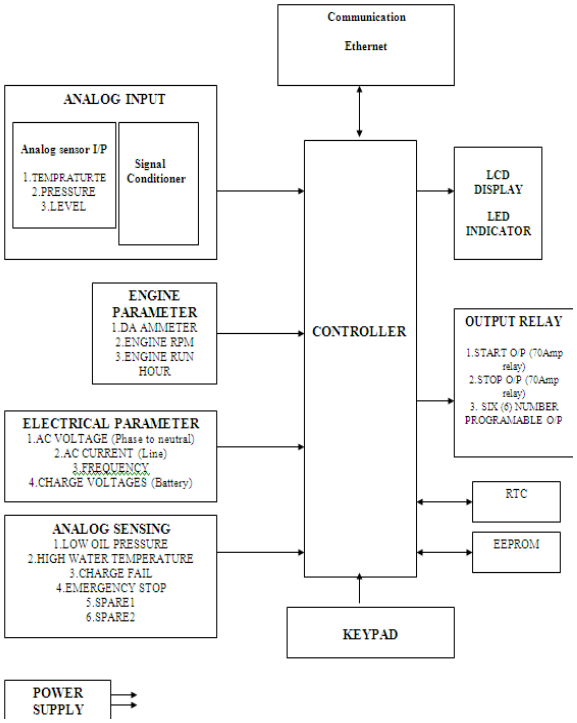

Fig2: Block diagram of embedded automatic transfer switch

I have decided to develop the system **"An Embedded 1/3Phase Automatic Transfer Switch Controller with Intelligent Energy Management"**because my aim of the paper is to automate the Generating Set with Programming Parameters accessed from Remote place.

So, I have decided it to implement protogen unit.

The unit is a control and protection panel used in gensets. It shows the measured values on its displays. The unit is designed to provide user friendliness for both the installer and the user. Programming is usually unnecessary, as the factory settings have been carefully selected to fit most applications.

However programmable parameters allow the complete control over the generating set. Programmed parameters are stored in a Non Volatile Memory and thus all information is retained even in the event of complete loss of power.

In my Project, I am basically concentrating on following applications such as

- Display of 3 phase Generator voltage, frequency and RPM,3 phase mains voltage,3 phase load current, date and time, KWH for mains and DG set, power factor of R,Y,B phases, fault log data, DG start-stop events, DG Battery voltage
- 39 programmable parameters(programming protected with password)
- Programmable current transformer ratio
- Programmable site code
- 11 Digital inputs, 12 Relay outputs
- Relay outputs for mains and generator contactor
- Fuel consumption per liter
- Log of Fuel consumption(optional)
- Remote monitoring of parameters-RS232 upon request

A. Operation

"PROTOGEN" has two basic operation modes, namely AUTO mode and MANUAL mode. In AUTO mode, "PROTOGEN" controls the GEN-SET automatically according to the parameter settings. Two push buttons ("START" and "STOP") have been provided to operate the engine manually (MANUAL mode).

Auto mode: To enter into the AUTO modeSwitch ON the Auto/Manual Switch of the Control Panel to "AUTO" Position."AUTO MODE OPERATION." message will be displayed on the LCD.[5,6]

B. Auto mode:

To enter into the AUTO modeSwitch ON the Auto/Manual Switch of the Control Panel to "AUTO" Position."AUTO MODE OPERATION." message will be displayed on the LCD [5,6].

C. Failure of Mains Power:

When mains power fails due to any fault in the system, "PROTOGEN" initiates an auto-start sequence to start the GEN-SET. After successful start of the GEN-SET, the load is transferred from mains to "PROTOGEN" automatically. However, in case of phase reversal, "Phase Reverse Message" appears on the LCD for corrective action.[5,6]

ISSN 2249-6343
International Journal of Computer Technology and Electronics Engineering (IJCTEE)
Volume 3, Issue 2, April 2013

D. Starting Sequence:

Crank will given to generator. The LCD will display START MODE……..”Message. If the Generator starts within the number of attempts set in the program (programming parameter no.8), the load will get shifted to the Generator. If the Generator does not start within the programmed number of attempts, “FAIL TO START” message will be displayed for corrective action. [5,6]

E. Restoration of Load To Mains Power:

When mains supply returns to normal condition, “PROTOGEN” will transfer the load automatically from generator to mains after “mains restore time” (programming parameter no.4), through the mains contactor. The generator cool-down time will start thereafter. During the cool-down period the generator will run without load.[5,6]

F. MANUAL MODE:

The “PROTOGEN” unit is by default on MANUAL mode when power is ON. To enter in MANUAL mode, switch on the “Auto/Manual Switch” of the Control Panel to MANUAL position. “MANUAL MODE OPERAT.” message will be displayed on the LCD. In MANUAL mode, the GEN-SET can be started and stopped by means of two push buttons “START” and “STOP” on the front panel. The start/stop sequence relates to the parameter settings.[5,6]

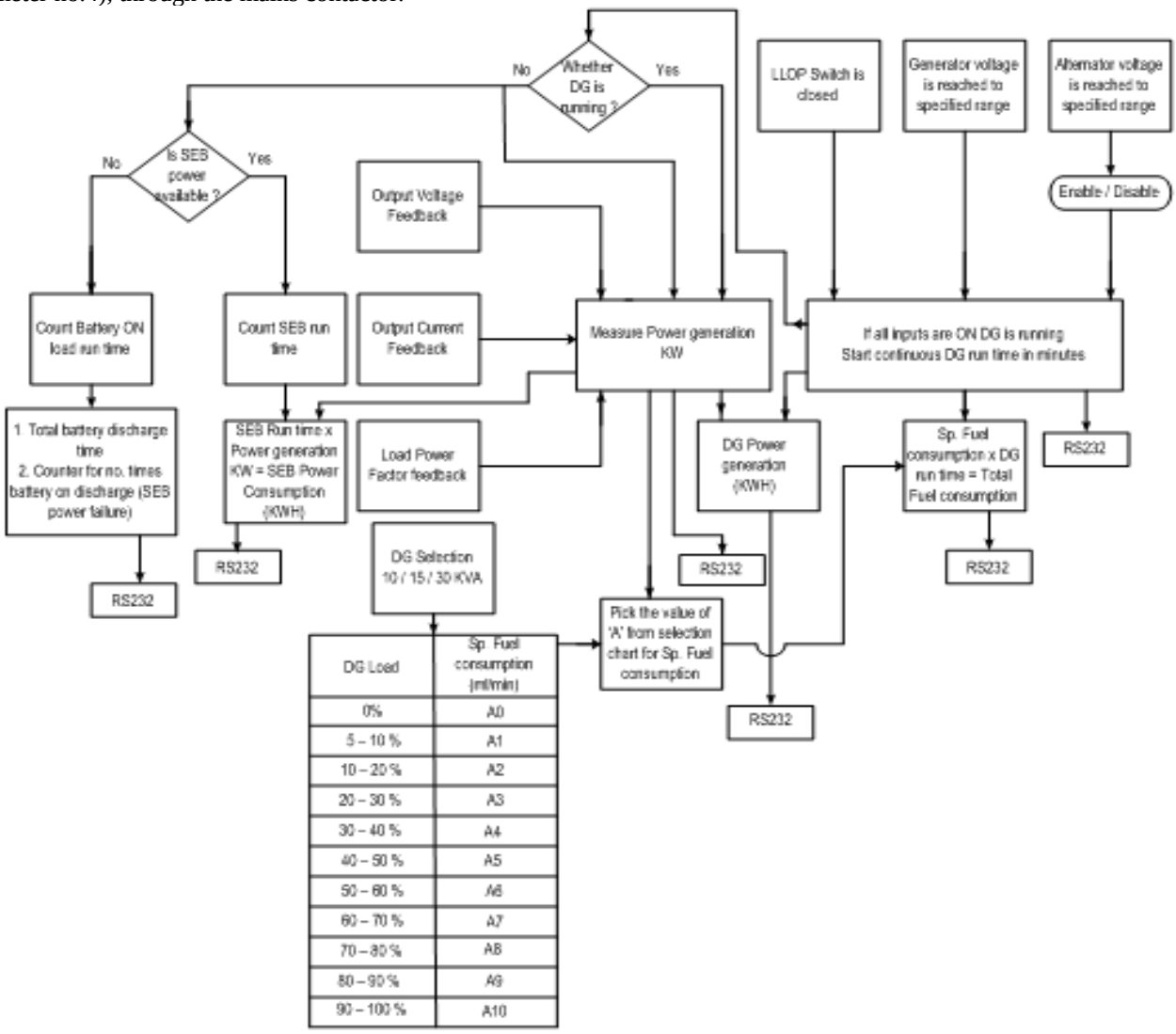

Fig3. Flowchart For Embedded ATS Switch

ISSN 2249-6343
International Journal of Computer Technology and Electronics Engineering (IJCTEE)
Volume 3, Issue 2, April 2013

Table 1: Program Parameters:

Para. No.	Details of Parameters	Range	Standard
1.	Mains Low Voltage	90 –210 Volts	170
2.	Mains High Voltage	250 -285 Volts	270
3.	Engine Start Delay	0 - 3600 Sec	5
4.	Mains Restore Time	0 – 300 Sec	15
5.	LLOP Bypass Time	0 – 99 Sec	15
6.	Stop Solenoid Time	10 – 99 Sec	25
7.	Crank Time	1 – 99 Sec	3
8.	Crank Attempts	1 - 5	3
9.	Crank Rest Time	1 – 99 Sec	15
10.	Engine Cooling Time	0 – 300 Sec	60
11.	Engine Warm-up Time	0 – 300 Sec	10
12.	DG Low Voltage	180 – 210 Volts	190
13.	DG High Voltage	250 – 285 Volts	265
14.	DG Max Run Time	0 – 1440 min ;0- Disable	0
15.	DG Low Frequency	43 – 47 Hz	46Hz
16.	DG High Frequency	53 – 59 Hz	53
17.	Over Load Current	0 – 1000 AMP	30
18.	Load C.T. Ratio	1 – 1000 Ratio	1
19.	Phase Unbalance	10 – 100 Volts	50
20.	Device ID	0- 255	32
21.	Remote Start	Yes – Enable; No - Disable	No
22.	Remote Stop	Yes – Enable; No - Disable	No
23.	GSM Modem	Yes – Enable; No - Disable	No
24.	Event ReportingThrough Modem	Report all Event; Report Fault Event; Disable	Disable
25.	Engine Preheat Time	0 – 300 Sec	0
26.	Engine Periodic Start	0 – 90Days	0
27.	Engine Rest Time	0 – 10 Hrs	0
28.	Engine Periodic Run	0 – 300 Minutes	0
29.	Set Low Battery Volt	8.0V- 24.0V	10.0v
30.	Set Hooter Timeout	0-900sec (0-Disable)	120sec
31.	Change password	0 - 9999	1000
32.	Alphanumeric Site ID	20 digit; Can set 0-9-A-Z	-
33.	Setting Options	Delete/Reset Option, PC To Unit Copy	-
34.	DG Stop option	ETS/ETR	ETS
35.	LCD Back light options:	Continuous ON/Power saving mode.	Continuous ON
36.	Mains Failure Time	0 – 250 Sec	6 Sec
37.	Configuration Of DI3 input	Door open or Fire/smoke input	Fire/smoke
38.	Oil sensor / wiring fault alarm	On Or OFF	ON
39.	Mains Fail alarm	On Or OFF	OFF

ISSN 2249-6343
International Journal of Computer Technology and Electronics Engineering (IJCTEE)
Volume 3, Issue 2, April 2013

IV. Applications Of ATS Switch

1) A multinational bank operations center performing critical 7 x 24 operations cannot sustain an outage without substantial losses and disruption to global operations.
2) A telecommunications site that hosts multitudes of users cannot go down without loss of revenues and credibility with its customers.
3) A boiler control system of a power plant supporting a major manufacturing operation cannot be disabled without substantial cost of recovery and degradation of product quality.
4) Loss of power to computers and display systems at a major air traffic control center poses risks to passenger safety as well as causing flight delays.
5) Loss of power to systems controlling tools, ovens, and apparatus that manufacture intricate microelectronics can cause lost product, delays in shipment, and loss of quality.
6) Home use of transfer switch-homes with standby generator may use a transfer switch for a few circuits or the whole home. Different models are available, with both manual and automatic transfer. Often small transfer switch system use circuit breakers with an external operating linkage as the switching mechanism. The linkage operates two circuit breakers in tandem, closing one while opening the other. Manufactures of transfer switches can provide recommended installation procedures. Like all other electrical apparatus, local electrical codes require transfer switches to carry safety approvals. However, some transfer switches are sold via the Internet, and there have been problems with counterfeit circuit breakers.

V. Conclusion

The aim of paper is to present embedded ATS switch and highlights their use in industry, mobile tower applications. It has been underlined that this hardware solution can perfectly address the current challenges in these fields such as high control performance, reliability and efficiency. Programmable parameters allow the complete control over the generating set.

Acknowledgment

This project sponsored by Cologicx Systems Private Limited, Embedded Business Solution. Author would like to thank Mr. Wasudev Deshmukh,Chief Manager for their support and involving in the discussion throughout the experiment.

REFERENCES

[1] An article on “Energy conservation in India” by Shri P M Sayeed, Hon‟ ble Minister of Power‟ s article on the occasion of Energy Conservation Day, on 14th December 2005.
[2] Y.Sung Song,K.Deok Moon.”Home Energy Management System Based on Power line communication”.978-1-4244-4316-1/10IEEE2010.
[3] Yong Hua Song and Allan T Johns”Flexible ac transmission System “The Institution of Electrical Engineers, London, Uniited Kigdom1999.
[4] Hingarani, N.G.”High power Electronics and Flexible AC Transmission System”, Power Engineering Review, IEEE, Volume: 8.Issue:7, July1988, pages3-4.
[5] Barnini, Datakom User Manual.
[6] Utopia Automation and control Pvt.Ltd. User operation manual.
[7] Anoop R, Anup J Nambiar, Prathap R, Sridhar Divakar, Dr. T B Isha “Condition monitoring of Diesel generator using PC”.
[8] Paper on “Automatic transfer switch (ATS) based on a programmable logic controller (PLC)”, Mechatronics, 2004, ICM '04. Proceedings of the IEEE International Conference, Issue: 3-5 June 2004,pages:531-535.
[9] High voltage high-speed vacuum automatic transfer switch (ATS), Harmonics and Quality of Power, 2000 Proceedings, Ninth International Conference, Issue2000,volume:3,pages:882-886.
[10] Book entitled by “Maintaining Mission Critical Systems in a 24/ Environment”, Publisher: Wiley-IEEE Press, Pages: 89 -111, Subject Categories: Power, Energy, & Industry Applications.